A Dissertation On

EVALUATION OF EFFECT OF STEAM BATH ON PULMONARY FUNCTION IN HEALTHY VOLUNTEERS

Submitted by

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I, Dr.M.PANDIARAJA solemnly declare that dissertation titled "**A STUDY ON EVALUATION OF EFFECT OF STEAM BATH ON PULMONARY FUNCTION OF HEALTHY VOLUNTEERS"** is a bonafide and genuine research work carried by me at Government Yoga and Naturopathy Medical College and Hospital, Chennai from July 2016 - June 2017 under the guidance and supervision of Dr.N.MANAVALAN N.D. (OSM), M.A (G.T), M.SC(Y&N), M. Phil, P.G.D.Y, P.G.D.H.M, P.G.D.H.H., Head of the Department - Department of Naturopathy .This dissertation is submitted to The Tamilnadu DR.M.G.R. Medical University towards partial fulfillment of requirement for the award of M.D. Degree (Branch - I) in Naturopathy.

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The proposal is APPROVED.

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ABBREVIATIONS

(IN ALPHABETICAL ORDER)

BMI	Body mass Index
DBP	Diastolic Blood Pressure
FVC	Forced vital capacity
FEV1	Forced Expiratory Volume in 1 Second
FEV1/FVC ratio	Forced Expiratory Volume in 1 Second / Forced vital capacity ratio
FEF	Forced expiratory flow
HSPs	Heat Shock Proteins
HSP72	Heat Shock Proteins 72
L-NAME	L-Arginine Methyl Ester
MVV	Maximum Voluntary Ventilation

NO	Nitric Oxide
NOS	No Synthase
NK-1	Neurokinin-1
PFT	Pulmonary Function Test
PEFR	Peak Expiratory Flow Rate
PP	Pulse Pressure
SBP	Systolic Blood Pressure
SVC	Slow Vital Capacity
VIP	Vasoactive Intestinal Peptide
WHR	Waist hip ratio

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ABSTRACT

Introduction:

Steam bath though used extensively all over the world yet its physiological influence has to get explored. The aim of the present study was to examine the effects of steam bath on pulmonary function parameters in healthy volunteers. Among pulmonary function parameters, PEFR, being a long term indicator of morbidity and a marker of health was considered and compared. We compared PEFR pre and post values, to reveal steam bath`s influence over respiratory system.

Aim:

To evaluate the effect of steam bath on pulmonary function in healthy volunteers.

Methods:

Forty healthy volunteers of both the sexes (Mean±SD Age (Yr) 16.38±1.98, Height (cm) 151.2±8.27, Weight (Kg) 56.53±14.68, BMI (Kg/m2)19.2±2.89) were selected and underwent steam bath. Steam bath was given once a week, each session of fifteen minutes for twelve weeks. The pulmonary function parameters (PEFR, FVC, FEV1, SVC and MVV) were measured by spirometer and anthropometric measurements

such as BMI, height, weight and blood pressure were recorded before the steam bath at the beginning of the study as baseline value and at the end of the twelfth week at the end of the study and compared.

Results:

In this study the values of PEFR, SVC, MVV showed significant improvement ($p< 0.05$), which reflects the improvement of lung function while the cardiovascular parameters also got significant ($P <0.05$) reduction reveals the parasympathetic dominance after steam bath intervention. Also the waist hip ratio got significant ($p< 0.01$) reduction. R statistical software free version3.2.0 and paired T test were used for data analysis.

Conclusion:

Steam bath is evidence based effective intervention in improving lung function as well as basal metabolic rate.

Keyword: Steam bath; heat stress; temperature regulation; parasympathetic nervous system; respiration; lung function

1.INTRODUCTION

Naturopathy system of medicine or Complementary and alternative system of Medicine (CAM) aims at wellbeing of the community through natural way of living and also it treats the human diseases through natural elements. Naturopathy aims in prevention than in cure hence naturopathy always plays a vital role in primary health care through healthy life style, natural therapeutics, natural diet and healthy conduct. Among the five elements, water plays a major role in naturopathy as equal to the other elements in the form of hydrotherapy. Steam bath is one of the hydrothermal modality widely used in naturopathy.

Steam baths, saunas, whirlpools, and solariums are standard therapies of many spa resorts, with the main objective being to relax and strengthen the body and mind and to prevent development of disease. **(A van Tubergen and S van der Linden 2002)**

Steam bath is found to be effective therapeutically in many diseased conditions such as gout, fever, inflammation, infectious diseases **(Bilz F.E 1898)** obesity, chronic rheumatism and chronic rheumatism with obesity, Bright's disease, auto intoxications, chronic alcoholism, jaundice, tertiary syphilis, as well as neuralgia, sciatica, peripheral paralysis and exudative meningitis of the spine. **(Kellogg J.H.1904)**

The primary function of the respiratory system is to maintain normality of arterial blood gases, that is, arterial pressure of oxygen (PO2) and arterial pressure of carbon dioxide (PCO2). To achieve this goal, several processes must be accomplished, including alveolar ventilation, pulmonary perfusion, ventilation - perfusion matching, and gas transfer across the alveolar - capillary membrane. Pulmonary function is a long-term predictor of mortality in the general population **(Holger J. Schu¨nemann et al., 2000)** and Peak expiratory flow rate (PEFR) is a reliable indicator of the lung function. **(Schu H.J. et al., 2000)**

Peak Expiratory Flow Rate (PEFR) as a measurement of ventilatory function was introduced by Adorn in 1942, and was accepted in 1949 as an index of spirometry **(Holger J. Schu¨nemann et al., 2000)**. By definition, it is "the largest expiratory flow rate achieved with a maximally forced effort from a position of maximal inspiration, expressed in litres/min". **(American Thoracic Society: Standardization of Spirometry; 1994 update)** PEFR is considered as the simplest index of pulmonary function to assess the ventilatory capacity. It is effort dependent and reflects mainly the calibre of the bronchi and larger bronchioles, which are subjected to reflex broncho constriction. **(Gabriel Laszlo 2006)** It is relatively a simple procedure, and may be carried out in the field using portable instruments. The average PEFR of healthy

young Indian males and females are around 500 and 350 litres /minute respectively. **(Dikshit M.B. et al., 2005)**

The PEFR reaches a peak at about 18-20 years, maintains this level up to about 30 years in males, and about 40 years in females, and then declines with age.

Though steam bath is beneficial in health promotion **(Avan Tubergen 2002)** as well as in many diseased conditions, its influence over pulmonary function of healthy population is not yet studied. Thus the aim of the study is to find out the effect of steam bath over pulmonary function especially in terms of peak expiratory flow using spirometer, as Peak expiratory flow rate (PEFR) is a reliable indicator of the lung function. Though there were studies **(Walter J. Crinnion 2011)** done in the topic of sauna bath as well as PEFR there are very few studies relating steam bath with PEFR which is not sufficient to understand in depth about the physiological influence of steam bath over respiration.

Hence through this study it is hypothesized that steam bath will improve the lung function in healthy individuals. Through this research it would be possible to validate the use of steam bath as evidence based therapy in its role in influencing the respiratory system positively especially in terms of PEFR.

2. AIMS AND OBJECTIVES

Aim

To evaluate the effect of steam bath on pulmonary function in healthy volunteers.

Objectives

1. To evaluate the effect of steam bath on pulmonary function in healthy volunteers.

2. To evaluate the effect of steam bath on BMI and Waist Hip ratio in healthy volunteers.

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3.1. Steam bath Introduction

Steam bath being the most widely used hydrotherapy treatment. History of steam bath starts with Naturopathy, a system of medicine in which water is a main contributor in health especially as preventive.

3.2. Definition

A body steam bath in which there is 100% humidity, given with the person sitting on a wooden chair, covered with a non-flammable plastic sheet. As the steam in the Russian Bath condenses; it liberates large amounts of heat, 537 calories for each gram. Thus there is an intense heating effect. **(Kellogg J.H.1904)**

3.3. History of Steam bath

Taking the waters used to be a popular treatment for a wide range of diseases in classical times. The Greeks preferred baths in fresh water from natural resources, although bathing in the sea (thalassotherapy) was also applied. Initially, bathing was confined to the more wealthy people in private baths, but soon public baths were opened. The baths were considered sacred places and were dedicated to several deities. **(Croutier AL. 1992) (Jackson R. 1990) (Schadewalt H. 1989)**

Sauna is one of the most joyful activities humanity has ever created. Thousands of years old, the invention sometimes known as the 'Finnish bath' has counterparts across the world – the neighbouring Russian banya to the Japanese *sentō* and *mushi-buro,* to the Islamic hammam and its Westernization as the Turkish bath, to the Mesoamerican *temescal* and the North American sweat lodges – all of which deliver the unique and blissful experience that Sigfried Giedion called "total regeneration". Regeneration can be obtained by means other than sweat bathing (e.g. a hot spring), but the combination of hot air and water vapour delivers a truly special form of mental and physical replenishment. **(Giedion, 1948)**

Recognised as a profoundly social form of bathing, the most famous celebration of this tradition is Mikkel Aaland's classic book *Sweat* (1978) since the mid twentieth century sauna has become an increasingly global phenomenon, capturing the imagination, warming bones, and neutralizing stress from Norway to Antartica.**(Svati Kirsten Narula 2014**

In Homeric times, bathing was primarily used for cleansing and hygienic purposes. By the time of Hippocrates (460–370 BC), bathing was considered more than a simple hygienic measure; it was healthy and beneficial for most diseases. **(Jackson R. 1990)**

Hippocrates proposed the hypothesis that the cause of all diseases lay in an imbalance of the bodily fluids. To regain the balance a change of habits and environment was advised, which included bathing, perspiration, walking, and massages. **(Looman J. 1989)** The baths were often combined with sports and education, the precursors of the gymnasium.

Influenced by the Greeks, the Romans built their own thermal baths at mineral and thermal springs. Asclepiades (*c* 124 BC), a Greek physician who practised in Rome, introduced general hydrotherapy and drinking cures as treatments. **(Schadewalt H. 1989)**

He recommended bathing for both therapeutic and preventative purposes. Pliny the Elder (AD 23–79) assigned different properties and indications for cure to different types of waters. **(Schadewalt.H 1989) (Routh H.B. 1996)**

Galen (AD 131–201) also advocated the use of water for the treatment of a variety of diseases. **(Routh H.B. 1996)**

Steam baths, saunas, whirlpools, and solariums are standard equipment of many such spa resorts, with the main objective being to relax and

strengthen the body and mind, and to prevent development of disease. **(A van Tubergen, 2002)**

Greek Baths (500 – 31 BC)

This section will cover a huge span of time: the Ancient Greek period, Roman and Byzantine Empires before proceeding to the Ottoman Empire as the last point in this historical line. It aims at showing different developments of bathing cultures and especially with regards to Ottoman hamams, it will seek to specify particular meanings and cultural expression of Turkish baths both in its physical and immaterial forms.

The Ancient Greek times existed already a long time before 500 BC. However two periods are analysed in this chapter since the first forms of the communal baths and bathing appeared roughly in the 5th or early 4th centuries BC. This time of history is commonly divided into two periods: classical period (500 – 323 BC) and Hellenistic that started after the conquests and death of Alexander the Great (323 – 31 BC). There were two main bathing establishments in Ancient Greece namely gymnasium baths that were designated exclusively for male athletes after performing exercises and balaneia, an independent architectural unit used for secular

purposes. Sometimes sanctuary baths devoted for ritual ceremonies are referred to as the third type yet they will not be analysed since only the first two bathing establishments are relevant in order to show development of communal baths that started during the Ancient Greek times.

The first type of baths that is found in gymnasium was an important social centre for male citizens of Greece. It was a large institution initially devoted to various physical exercises that later gradually expanded its facilities also to intellectual and educational functions. Thus, for instance, libraries and rooms for public lectures noticeably increased in number especially in the middle of the 4th century BC and eventually gymnasiums became more focused on mental education rather than athletic. This changing philosophy of education subsequently brought fusion of two different bathing entities, i.e. balaneia and gymnasium baths, in terms of terminology and architecture. After the renovation of gymnasiums, for instance, the same building could be confusingly called either balaneia or gymnasium. Yegül suggests that this fusion happened due to several reasons: the decline of the athletic use of gymnasiums and the rising popularity of hot baths. **(Yegül 1992)**

The only known element attached to bathing and washing in gymnasium is loutron, a coldwater washing room, which was also regarded “morally superior” to heated baths. **(Yegül 1992, Farrington 1999)** Loutron appeared roughly in the late 5th or early 4th century BC, which indicates the initiation, as Yegül suggests, of one of the first forms of communal bathing due to its social and architectural context. **(Yegül 1992)**

They were usually located in one of the corners of palaestra and could be exclusively used by the athletes or the visitors of the gymnasium. All in all, bathing was associated with cleanliness of body and spirit; therefore it soon became an important component of daily gymnasium programmes, which kept an important balance between physical and intellectual elements.

The second type of bathing establishment in Ancient Greece, balaneia, in urban centres started to exist from the 5th century BC around the time when baths (loutron) were introduced in the gymnasiums.

One of the remarked characteristics of Greek balaneia planning is that they were marked with ‘simplicity and functionalism’. **(Yegül 1992)**

They were rectangular or irregular shaped units attached around a tholos, which is an important architectural element employed in Greek baths8. Furthermore, these baths were small and with no defined order of use or principle of temperature gradation of each room. Yet some Greek balaneia could have a simple version of a hypocaust9 system, which can be found, for instance, in Gortys, Arcadia or in Olympia, Greece. **(Lawrence 1983, Yegül 2002)** At the same time, some Greek baths could be heated by steam produced by braziers or by hot water. Primarily, the circular rooms were reserved for hot bathing.

The ground plan of Gortys in Arcadia shows a typical architectural example of balaneia in Ancient Greece. **(Yegül 1992)** In the plan one sees rectangular units, which are clustered around two large tholos. The structures around tholos are devoted to secondary use like undressing room and entrances and service like furnace and boilers. A third tholos could have been a dry room. **(Yegül 1992)** which is enclosed like other circular and rectangular units into a square structure.

Another significant characteristic of Ancient Greek baths is the presence of individual tubes or so called “hip baths” that could be located in a tholos or a rectangular room arranged side by side along the wall. **(Yegül 1992)** Two types of bathing structures, one in gymnasium and the other

an independent unit balaneia, indicate the first known formation of communal bathing in the Classical world. As a social centre the gymnasium was more important than the balaneia, therefore the gymnasium baths spread especially fast to other conquered colonies during Hellenistic time since gymnasiums were a focal point of every newly founded settlement and city. Although Yegül indicates that gymnasium baths were “one of the earliest form of communal bathing” **(Yegül 1992)**, only the male athletes could use them, therefore “community” was rather limited to the privileged contingent of people. On the other hand, people who were non athletes used balaneia for bathing. No physical exercises were connected to Greek balaneia, therefore it might indicate that Greeks bathed in balaneia for hygienic reasons rather than social since individual bathing manner was promoted in Greek baths without communal exercises before, which induced socialising among people.

Finally, Ancient Greek bathing traditions influenced a bathing development of the Roman times. As Nielsen argues, the Roman baths were inspired by Greek balaneia as well as by the Greek palaestra “which were transformed by the invention of concrete and of the developed

hypocaust system into one, or rather two, new building types: the balnea and thermae.” **(Nielsen 1999)**

Roman Baths (31 BC – 476 AD)

Augustus is known for restoring the Republic of Rome, which was marked by political crisis and dictatorship during the preceding centuries. He turned the Roman State into the Roman Empire in 31 BC that eventually dominated Western Eurasia. The rule of the Roman Empire underwent economic chaos and political upheavals, autocracy and civil wars that led to the division of the Empire into two halves, the West and the East. The latter is known as the Byzantine Empire. West Rome eventually disappeared in 476 AD. During this long reign public baths became an indispensable part of Roman life for the maintenance of health and for social reasons. At the same time, public baths retained many symbolic meanings and readings that provide an interesting view on Roman civilization, which will be outlined below.

Before proceeding to explain the bathing culture in the Roman Empire, two bathing establishments in ancient Rome should be explained: balnea and thermae.

The terminology is rather confusing, however it is mostly agreed that the main differences underlined are in terms of ownership and scale**. (Meiggs 1973, Yegül 1992)** Balnea is small and privately owned; thermae, on the other hand, is an exceptionally large public bathing complex. Nielsen adds to that that balnea had only bathing function and thermae contained at least a sport section, which was inspired by the Greek palaestra. Fagan also mentions that the first bathing establishment was relatively unadorned, but thermae were famous for their luxury and decorations. **(Fagan 1999)** For clarification of terminology the next paragraph will look at the thermae.

Thermae is a huge complex of buildings with lecture halls, libraries, pools, art galleries and many other practical facilities comprising such a grand scale that a few thousand people could take a bath at one time, a grandiosity that no other culture could ever match. The scale of the bath was described and compared by some scholars as “a city within a city” or “microcosm” within the Roman Empire. **(Zajac 1999)** Romans also made some technical improvements and innovation in thermae. They advanced

a hypocaust heating system and introduced a system of the baths, which was based on a gradation of rooms according to temperature.

This system was unique.Baths of the Roman times can be read as symbols, which give a deeper insight into the social and political life of the Empire. In particular DeLaine and Zajac emphasise that huge and luxurious baths were a manifestation of omnipotent power of the emperors and Rome. **(De Laine 1999)** It was an indication of their supremacy, which was made concrete by means of architecture. **(Zajac 1999)** Furthermore, through advancement o technology Romans symbolically and literally manifested power over and even wanted to tame nature, especially water, which is a wild and unpredictable resource **(Fagan 1999, Zajac 1999)** In short, Ancient Roman baths symbolised physical and political greatness of the Empire as well as power and superiority over nature.

In addition, bathing for Romans was one of the means of Romanization that distinguished the civilized from the barbarian. **(DeLaine 1999, Nielsen 1999)** This hypothesis also emphasised the “cult of body” during the Ancient Roman times. Therefore, a great care was performed over one’s physical body and health that eventually defined one’s status of being a citizen of Rome.

The public bath of Caracalla is the second largest Roman bath complex ever built, which accommodated 1,600 bathers at a time and occupied an area of about 120,000 square meters. **(Yegül 1992)** Though huge in scale,

the Thermae of Caracalla represented a simplicity in planning and often, together with another grandscaled Thermae of Diocletian, appears to be "…a textbook example of the fully developed large imperial type in Rome." (Ibid.)

If one is to simplify a plan of the Thermae of Caracalla, one can see the circle of the caldarium situated on the South, which represented the centre of two symmetrical parts of the building. The plan of thermae shows that longitudinally the bath is divided into five parts.

The central part caldarium (hot room), tepidarium (intermediate room), frigidarium (cold room), natatio (a cold pool) and the end part palaestra are the main functional parts. The service and dressing rooms are located between the functional parts of the baths. The palaestra could be entered through the hot rooms on the south side and through the entrance halls on the north. One could also choose the other bathing route based on individual preferences and wishes.

The main rooms in a thermae are apodyterium, caldarium, tepidarium and frigidarium, which can be also treated as a common sequence to be followed by a bather. Usually people would come to baths after doing exercises in palaestra; they would go to the changing room (apodyterium) and then head towards the hottest area of the bath (caldarium), taking a route through an intermediate hot room (tepidarium) where they used to get accustomed with the heat.

Lastly one could go to the cold room (frigidarium), and immerse oneself into a cold pool (na tatio). Some baths had laconicum, which is a very hot dry-steam room where one stays there very briefly. Romans made bathing a part of their culture and daily routine that most of the social classes were able to enjoy. It was a ‘microcosm’ within the Roman Empire that represented physical and political power as well as superiority over nature. At the same time, the real success and development of baths came with the discovery of advanced hypocaust system and the gradation of rooms according to temperature that was eventually passed on and adopted by the following cultures. Turkish baths (*hamams*) in Istanbul built after 1453 provide the classical Ottoman bath pattern as the basis for the following research. As some scientific accounts reveal, total 237 public baths were built in Istanbul,

yet some of them are not traceable, the locations of some of those are also unknown. **(Haskan, Yılmazkaya, 2003)** Furthermore, there were many private hamams built in rich people houses and Sultan's family palace. However, two types of baths should be distinguished in Turkish culture: *ılıca*, which is built on thermal water resources and used mostly for health reasons and hamam, which is a steam bath.

John Harvey Kellogg's massive book, Rational Hydrotherapy, had added enormously to understanding the benefits of this long-forgotten therapy. Kellogg referred to the steam bath as the vapor bath, and he gives an account of Wilhelm Winternitz's innovative steam bath taken in an ordinary bathtub. Winternitz devised "a board of a size sufficient to support the patient, and perforated with inch holes laid in the tub and raised by proper support three or four inches from the bottom." (Kellogg J.H. 1904) A hose was attached to the faucet and laid down under the board to the head of the tub. As hot water emptied into the tub, steam was generated, and with the tub unplugged, hot water left. "The vapor is retained about the body of the patient by blankets placed over the top of the tub, and tucked around the neck in such a way as to protect the head from the warm vapor."**(Kellog J.H. 1904)**

3.4. THE RUSSIAN BATH

In this bath the patient lies upon a slab in a small room filled with steam, being rubbed at intervals by an attendant so as to promote the early appearance of perspiration. The temperature of the room is usually from 115° to 120°F; 140°F *is* barely endurable, but cannot be continued for any great length of time without danger. The length of the bath may be from 10 to 20 minutes. A cold shower bath is sometimes arranged in the apartment, so that the patient can, if he desires, expose himself to the alternate action of heat and cold by stepping under the shower bath for a few moments. In Finland a Russian bath is produced by pouring water upon heated stones in a room provided for the purpose. This method is essentially the same as that used from the earliest times by the North American Indians.

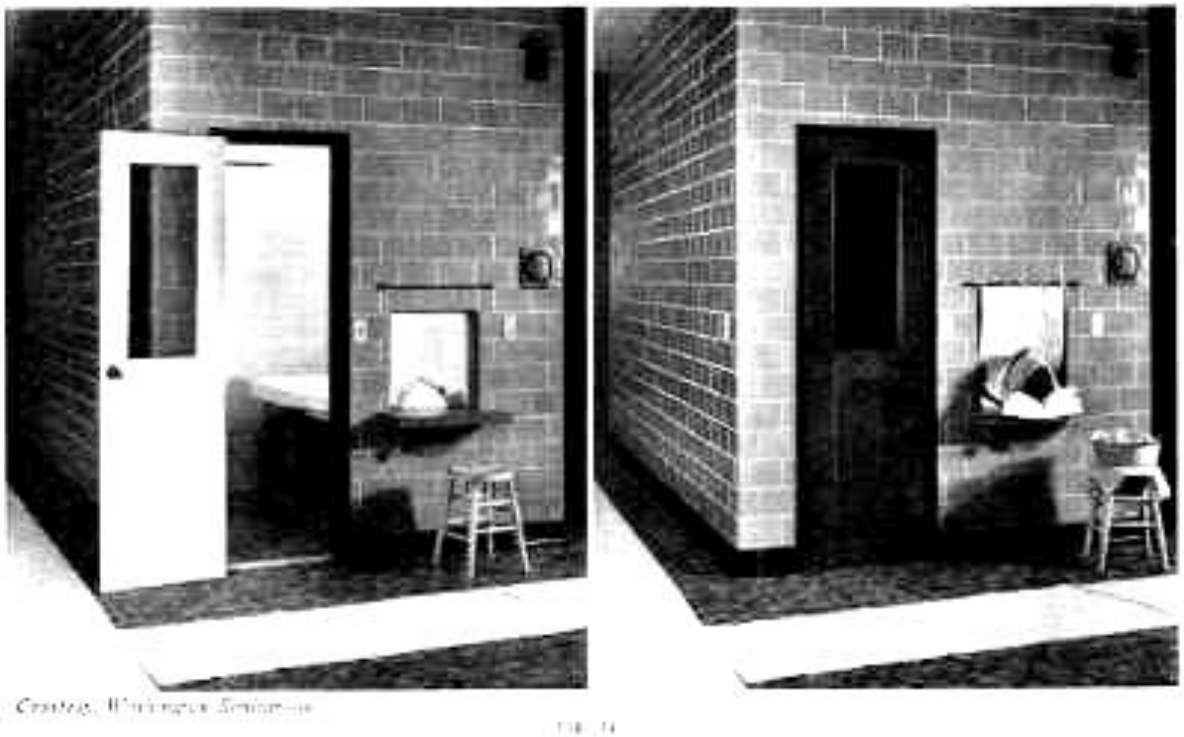
The Russian bath, like the Turkish, is followed by a shampoo and a cold shower or plunge bath. The same precautions should be observed at the conclusion of the bath respecting the cooling of the patient, as elsewhere indicated.

Physiological Effects: The effects of the Russian bath are essentially the same as those of the hot-air bath ; but to the ordinary effects of other hot baths the Russian bath adds one disagreeable feature,the interference

with the respiratory process, because of the saturated condition of the atmosphere of the bath. The elimination of CO2 is diminished in the Russian bath, and perspiration is less active than in the Turkish or the hot air bath at a temperature equally endurable.

httpwww.traditionalhydrotherapy.comimagesRussBth2.jpg

One advantage possessed by the Russian bath over the Turkish or hot-air bath is that it is better tolerated by persons suffering from eruptions or cutaneous irritation of any sort.



http://www.traditionalhydrotherapy.com/images/Russian.jpg

Perhaps the most important characteristic of the Russian bath is the rapid and considerable rise of body temperature, due to the interference with heat elimination through the skin and lungs, as well as by the heat communicated. The body temperature rises higher and more rapidly in the Russian than in the hot-air or the Turkish bath. As a result, the

oxidation of proteid elements is greatly increased, the condition being allied to that of fever. This increased oxidation of nitrogen gives to the Russian as well as the vapor bath and the sweating pack a special value in the treatment of chronic rheumatism and all forms of uric-acid poisoning and chronic toxemias, in which one of the chief indications is for increased oxidation and destruction of nitrogen-containing wastes and toxins. There is no bath which excels the Russian in this particular, except the electric-light bath, which rapidly heats the body, not by retention of body heat, but by the penetration of the rays of radiant energy into the depths of the tissues and powerfully excites metabolism.

Therapeutic Applications:

These are essentially the same as those already mentioned in relation to the hot-air bath and the Turkish bath. The Russian bath is for some persons more agreeable than the Turkish or hot-air bath, because of the effect of the moist air upon the skin. Persons suffering from acute bronchial catarrh often experience very great teoiporary relief in the Russian bath. Its effect is likely to be transient, however; and unless extraordinary precautions are taken, the exposure ordinarily necessary after the bath is likely to result in an aggravation of the cold. The Russian bath whitens the skin by improving its circulation, relieves rheumatic pain, and may be advantageously employed in diabetes when

there is no cardiac complication, in the chronic toxemia of dyspepsia, and in some skin disorders in which Turkish and water baths prove too irritating; it relieves pain in sciatica and is generally useful in the rheumatic diathesis.

The Russian bath is not so well adapted to the treatment of cases of obesity as is the hot-air or the electric-light bath or the sweating pack. The reason for this is the tendency in obesity to overheating and systemic weakening in consequence of the exhaustion of the nerve centers.

Contraindications:

Extra ordinary care must be exercised to avoid overheating the patient in this bath, as heat elimination is almost altogether suspended; and hence the bath must be avoided in febrile cases. The bath must also be interdicted in cases of cardiac weakness, in most cases of advanced Bright's disease, pulmonary tuberculosis, and in arteriosclerosis. **(Kellogg J.H. 1904)**

3.5. THE RUSSIAN BATH

The Russian bath consists in the immersion of the body in hot vapor. The steam, as it is turned into the Russian room, partially condenses and hangs suspended as a thick fog. For every gram of steam that thus condenses, 537 calories of heat are liberated. This fact accounts for the intense heating effect obtained by the use of this form of hot treatment. For the Russian bath provide a steam tight room with a marble slab. A sliding window should be so arranged at the end of the slab that the patient's head may be outside of the steam room. The steam should enter below the slab so as not to strike the patient directly, and be controlled by a valve near the sliding window so that the attendant may regulate the amount of steam and keep the head cool at the same time by frequently changed cold compresses to the head and neck.

Procedure:

Move the bowels by an enema and give a preliminary hot foot bath. Have the patient drink water before and frequently during the bath. This is necessary in order to provide for the profuse perspiration which the treatment should induce. See that the slab is warm; if not, pour over it several pails of hot water. Warm the room to about 100° F., and cover the slab with a folded sheet.

The patient is now assisted onto the table and lies on the back with the head on an air pillow just without the opening. The window is lowered and a towel wrung from ice water is placed about the neck, or hung across the lower end of the window and tucked around the neck. Another cold compress is applied to the head and covers the temporal arteries. A third cold compress should be applied to the precordia. In some cases it will be necessary to use an ice bag over the heart. Next turn on the steam, gradually raising the temperature of the room to 115°F or 120°F. A small amount of steam should be constantly escaping to maintain the temperature. Change the compresses to the head and neck frequently. The patient should be closely watched during the entire time of the treatment. The bath should last from ten to thirty minutes. Just before the patient rises from the slab, renew the ice compress to the head. Finish the treatment with a graduated or alternate spray or shower, or better still, a shampoo and graduated shower. The spray or shower should be in the Russian room or only a few steps from it.

Effects: The effects of vigorous sweating measures have been considered elsewhere. The "washing out" effect is, perhaps, the greatest; and the thoroughness of this depends very largely upon the water taken before and during the treatment. Sweating measures greatly increase

catabolism, especially of carbohydrates and fats. The products of nitrogenous metabolism show more complete oxidation.

The Russian bath is of great service in obesity, chronic rheumatism with obesity, gout, Bright's disease, autointoxications, chronic alcoholism, and in arteriosclerosis unless extreme. It is contra-indicated in diabetes, valvular heart disease, all diseases associated with emaciation and in extreme arteriosclerosis. **(George Knapp Abbott A. B. 1914)**

3.5.1. MECHANISM OF THERMO REGULATION

The body keeps its core temperature constant at about 37° C by physiological adjustments, controlled by the hypothalamus (Thermostat Center) where there are neurons sensitive to changes in skin and blood temperatures. The temperature-regulating centers are found in the Pre optic Area (the anterior portion of the hypothalamus). This area receives input from temperature receptors in the skin and mucous membranes (Peripheral Thermo receptors) and from internal structures (Central Thermo receptors), which include the hypothalamus itself. The temperature sensory signals from the pre optic area and those from the periphery are combined in the posterior hypothalamus to control the heat producing and conserving reactions of the body. The hypothalamic thermostat works in conjunction with other hypothalamic, autonomic and

higher nervous thermoregulatory centers to keep the core temperature constant. Some of these thermoregulatory responses are involuntary, mediated by the autonomic nervous system, some are neuro hormonal and others are semi-voluntary or voluntary behavioral responses.

3.6. PHYSIOLOGICAL RESPONSE TO HEAT EXPOSURE

When the body is exposed to heat (sun, fire, too much clothing), body temperature rises. Skin warmth receptors and blood convey these changes to the hypothalamic thermostat. The thermostat inhibits the adrenergic activity of the sympathetic nervous system, which control vasoconstriction and metabolic rate, thus causing cutaneous vasodilation and reducing BMR. This causes an increase in heat loss via the skin and a decrease in heat production in the core. If the heat is sufficiently intense, the cholinergic sympathetic fibers, which innervate sweat glands release ACh, stimulating sweat. Sweating is the most effective involuntary heat fighting response in man.

Thermal homeostasis is maintained by achieving a balance between the various avenues of heat gain and heat loss from the body. There are two recognized sources of heat load;

a) Environmental, which may be positive or negative, that is, there may be a heat gain or a heat loss from the body.

b) Metabolic, which is generated by muscular activity.

ENVIRONMENTAL FACTORSAFFECTINGTHERMOREGULATION

The principal methods of heat exchange between the body and the external environment are: convection, conduction, radiation and evaporation.

CONVECTION

The rate of convective exchange between the skin of a person and the ambient air in close proximity to the skin is dictated by the difference in temperature between the air and the skin temperature together with the rate of air movement over the skin. When the air temperature is greater than the skin temperature, there will be a gain in body heat from the surrounding air, conversely when the skin is warmer than the air temperature there will be a loss of heat from the body. Because warm air rises (less dense than cool air) the warm air will rise from the body and cool air will come in to take its place. This process is then repeated. The process is called convection.

RADIATION

The surface of the human body constantly emits heat in the form of electromagnetic waves. Simultaneously, all other dense objects are radiating heat. The rate of emission is determined by the absolute

temperature of the radiating surface. Thus if the surface of the body is warmer than the average of the various surfaces in the environment, net heat is lost, the rate being directly dependent on the temperature difference. This form of heat transfer does not require molecular contact with the warmer object. The sun is a powerful radiator, and exposure to it greatly decreases heat loss by radiation. When the temperature of the objects in the environment exceeds skin temperature, radiant heat energy is absorbed from the environment. Under these conditions the only avenue for heat loss is by evaporative cooling.

CONDUCTION

The difference between heat loss by conduction and radiation is that with conduction the body must be in contact with the object. In such circumstances the heat moves down its thermal gradient from the warmer to the cooler object, the heat energy being transferred from molecule to molecule. The warmer molecule slows down after it has lost some of its heat and the cooler molecules move faster having gained heat. The temperature transfer continues until eventually the temperature of the two objects equalizes. The rate of the heat transfer through conduction depends on the difference in temperature between the two objects and the thermal conductivity of the two objects.

EVAPORATION

When water evaporates from the surface of the skin, the heat required to transform it from a liquid to a gas is dissipated from the skin, this acts to cool the body.

Evaporative heat loss occurs from the respiratory tract lining as well as from the skin.

There is a constant gradual loss of water from the skin that is not related to sweat glands. The skin is not fully waterproof and so some water is lost out through pores in skin, and lost by evaporation. This loss is not subject to physiological control and is termed insensible perspiration. Sweating is an active process requiring energy and controlled by the sympathetic nervous system. The rate at which this process proceeds can be controlled and therefore the amount of heat loss can be controlled.

Radiation and convection are insufficient to prevent warming up of the body during heavy manual work or at high surrounding temperatures. Under these circumstances heat loss is aided by evaporation of water. At environmental temperatures above about 36 °C, heat is lost exclusively by evaporation. At higher temperatures heat is taken up by the body from the environment by radiation, conduction and convection.

Sweating then becomes profuse in order to maintain the balance between heat uptake and heat loss by evaporation. In order to be effective, sweat must be evaporated from the skin. If sweat merely drips from the surface of the skin or is wiped away, no heat will be lost.

In humans, hyperthermia leads to activation of a set of thermoregulatory responses that includes cutaneous vasodilation and sweating. Hyperthermia also increases ventilation in humans. **(Tsuji, B et al., 2016)**

One of the most striking features of the human cutaneous circulation is the wide range of blood flow this circulation is capable of attaining. Human skin blood flow can range from almost zero (in conditions of whole body and/or local cooling) to up to 8 l/min (or 60% of cardiac output) in conditions of severe heat stress. **(Johnson J.M. and Proppe D.W1996, Lowell L.B., 1989)** The skin circulation, therefore, has the complex capability of moving from very high to very low blood flows and controlling all levels in between to match the integrative requirements of human physiology. The level of blood flow in a given environmental or exercise condition is controlled by a complex interplay of reflex (whole body) and local control mechanisms, which influence both skin blood flow and each other. The focus of this review is on

reflex control of skin blood flow in humans, with brief discussions of some short- and long-term modifiers of this control. The mechanisms involved specifically in local control of skin blood flow are the focus of another review in this highlighted topics series **(Johnson J.M. and Kellogg D.L. 2010)**

The human skin circulation is best known for its role in thermoregulation. The ability of skin blood flow to reach such high

levels during body heating is necessary to increase convective heat transfer from the body core to the surface of the skin, and the resultant heat dissipation (in conjunction with sweating) is essential to the maintenance of normal body temperatures. Increased skin blood flow leads to increased skin blood volume, due to the arrangement of venous plexuses close to the skin surface **(Johnson J.M. and Proppe D.W. 1996, Lowell L.B. 1989)** Thus, with reflex cutaneous vasodilatation; more blood is transferred from the core to the surface of the skin, where heat transfer can occur. Under optimal conditions, the skin is cooled by evaporation of sweat, and the thermal gradient at the skin allows heat to dissipate from the blood to the skin and to the environment. The cooler blood is then transferred back to the body core, where it minimizes

increases in core temperature that occur during exercise and/or environmental heat exposure.

3.7. MECHANISMS OF REFLEX CUTANEOUS VASOCONSTRICTION AND VASODILATION

3.7.1. Reflex Cutaneous Vasoconstriction

The reflex innervation of the human skin circulation occurs via two branches of the sympathetic nervous system (Fig. 1). Sympathetic noradrenergic vasoconstrictor nerves provide tonic innervation, contributing to a relatively low skin blood flow at rest in normothermic environments (_250 ml/min) **(Brengelmann G.L. and Savage M.V. 1997)** Thus, in resting subjects in normothermic environments, interruption of sympathetic noradrenergic innervation of the skin [by various methods, including proximal nerve block and/or presynaptic inhibition with bretyl usually causes a small, passive vasodilation, due to withdrawal of the tonic activity of vasoconstrictor nerves. The extent of the passive vasodilation due to vasoconstrictor withdrawal depends on the thermal environment of the “baseline” condition (which leads to the extent of vasoconstrictor tone).

Thus, in warmer environments, there may be little to no passive vasodilation with interruption of vasoconstrictor innervation, whereas, in cooler environments, this vasodilation would be more pronounced. Even in cool environments, however, this passive vasodilation is several fold smaller than the reflex vasodilation that occurs during whole body heating or exercise.

Sympathetically mediated cutaneous vasoconstriction represents the "first line of defense" during exposure to cold environmental temperatures. Decreases in mean skin and/or internal temperatures cause reflex activation of sympathetic vasoconstrictor nerves, resulting in cutaneous vasoconstriction and decreases in skin blood flow. **(Charkoudian N. and Johnson J.M. 1999) (Stephens D.P et al. 2001)** Mechanisms involved in reflex cutaneous vasoconstriction are now recognized to be more complex than previously thought. Several studies have used prolonged ramp cooling protocols (15–45 min) in conjunction with pharmacological blockade to identify specific contributors and their roles in the vasoconstrictor response over a range of skin temperatures. In addition to norepinephrine mediated vasoconstriction,

Stephens et al. identified a role for noradrenergic cotransmitters in young men **(Stephens D.P. et al., 2001)** by using combinations of local presynaptic and postsynaptic (combined _1 and _2 inhibition) pharmacological blockade. Presynaptic inhibition of noradrenergic nerves was accomplished by local iontophoresis of bretylium tosylate, which is taken up specifically into presynaptic noradrenergic nerve terminals, where it blocks all neurotransmission from those nerves **(Haeusler G et al., 1969) (Kellogg D.L., Johnson J.M. and Kosiba W.A., 1989)** Using these approaches, Stephens et al. **(Stephens D.P. et al., 2004)** showed that complete postsynaptic blockade of nor epinephrine-mediated vasoconstriction did not completely inhibit the reflex vasoconstrictor response to 15 min of progressive decreases in skin temperature, although presynaptic inhibition with bretylium abolished the response. This suggested the existence of cotransmitter mediated vasoconstriction, which was later shown by the same group to be most likely mediated by neuropeptide Y, since antagonism of this peptide with BIBP-3226, along with double blockade of adrenergic receptors, abolished the reflex vasoconstrictor response **(Stephens D.P. et al., 2004)**

The authors also noted that the involvement of other vasoconstrictor cotransmitters, including ATP, should not be ruled out **(Stephens D.P et al., 2004)** Intracellular signaling for reflex cutaneous vasoconstriction includes activation of the Rho kinase pathway, the role of which becomes more prominent in older individuals **(Lang J.A.et al., 2009)**

3.7.2. Reflex Cutaneous Vasodilation

The question of what mediates the enormous increases in skin blood flow during heat stress has been an area of intense study (and some debate) over many decades. Dual sympathetic innervation of the skin (vasoconstrictor as well as vasodilator nerves) was first demonstrated in the 1930s **(Grant R.T. and Holling H.E. 1938, Lewis T. and Pickering G.W. 1931)**Sympathetic active vasodilator nerves do not exhibit tonic activity in normothermia, but, once activated during hyperthermia, are responsible for most (up to 90%) of the substantial vasodilation that can occur **(Johnson J.M. and Proppe D.W. 1996 , Lowell L.B. 1989)** The exact mechanisms for active vasodilation in human skin have proved elusive; however, several component mechanisms have been identified over the past 20 yr. Because active vasodilation and sweating are both important mechanisms of heat dissipation during whole body hyperthermia, investigators have proposed mechanistic links between the

two neural mechanisms (**Fox R.H. and Hilton S.M., 1958, Fox R.H. and Hilton S.M. 1956, Grant R.T. and Holling H.E. 1938)** Earlier ideas

were that cholinergic sudomotor nerves either caused active vasodilation themselves, or that they activated another substance (notably bradykinin), which then caused active vasodilation **(Fox R.H. and Hilton S.M. 1958, Grant R.T. and Holling H.E. 1938)**

Several investigators subsequently demonstrated that, while postsynaptic muscarinic receptor blockade with atropine completely abolishes sweating, it causes only minor delays or decreases in cutaneous active vasodilation **(Kellogg D.L. et al., 1995, Kolka M.A. and Stephenson L.A. 1987, Roddie I.C. et al., 1957)** Furthermore, direct intradermal blockade of bradykinin receptors does not alter skin blood flow responses during core hyperthermia, providing further evidence that bradykinin itself does not have a role **(Kellogg D.L. et al., 2002)**

A link to cholinergic innervation was demonstrated by Kellogg et al. **(Kellogg D.L. et al., 1995)** who used local administration of botulinum toxin to presynaptically block neurotransmission from cholinergic nerves. Botulinum toxin abolished active cutaneous vasodilation during body heating, whereas an attenuated vasodilator response occurred at sites pretreated with atropine (postsynaptic muscarinic receptor

blockade), as in previous work **(Kellogg D.L et al., 1995)** Taking together the evidence that presynaptic inhibition of cholinergic neurotransmission, but not postsynaptic muscarinic receptor blockade, blocked cutaneous active vasodilation, the authors concluded that an unidentified cholinergic cotransmitter was responsible for the vasodilator mechanism **(Kellogg D.L et al., 1995)**

Whether the cholinergic nerves in question are the same as the sudomotor nerves causing sweating in a given area is unclear, but appears unlikely based on existing evidence. Although the two responses occur generally in the same time frame (i.e., humans begin to dissipate heat when core temperature has increased by a few tenths of a degree Celsius), the temporal relationship between the onset (threshold) for sweating and the threshold for active vasodilation is not constant: one may occur before, after, or concurrently with the other in a given subject. Evidence against a single neural source for sweating and active vasodilation also comes from studies in which thresholds for sweating and thresholds for active vasodilation can shift independently of each other due to acute perturbations. For example, acute exercise shifts the core temperature threshold for active cutaneous vasodilation to higher

internal temperatures, but does not affect the threshold for sweating **(Kellogg D.L. et.al., 1991)**

More recent attempts to elucidate specific substance(s) responsible for cutaneous active vasodilation point to multiple possible contributors, reminiscent of multiple redundant mechanisms of vasodilation in exercising skeletal muscle (39). There is a significant contribution of nitric oxide (NO) to active cutaneous vasodilation, which is variable among individuals and averages _30% in young healthy people **(Kellogg D.L. et.al., 1998, Shastry S.et.al., 1998, Shastry S. et.al., 2000)**

Recent data from suggest that the NO component of reflex cutaneous vasodilation appears to originate primarily from neuronal NO synthase (NOS) rather than endothelial NOS **(Kellogg et.al., 1998)** However, inhibition of NO synthesis does not abolish active cutaneous vasodilation, indicating the existence of other vasodilator pathways that work in synergy with and/or complement the NO vasodilation pathway. An attractive candidate for “the” substance that causes active vasodilation in human skin has been vasoactive intestinal peptide (VIP), due to its known role as a vasodilator and its co localization in cholinergic nerve terminals. A role for VIP in human active vasodilation was suggested by a report of diminished active vasodilation during

intradermal microdialysis of the VIP antagonist VIP10–28. **(Bennett L.A. et al., 2003)** In a subsequent study, Wilkins et al. **(Wilkins B.W. et al., 2005)** did not find a decrease in active vasodilation during administration of VIP10–28. It is relevant in this context that the role of VIP in human skin has proven challenging to investigate due to limited receptor affinity of the available antagonist **(Bennett L.A.T et al., 2003)** and due to technical challenges associated with administration of a peptide via microdialysis. **(Wilkins B.W. et al., 2005)** Interestingly, in people with cystic fibrosis, in whom VIP levels in the skin are diminished, active cutaneous vasodilator responses appear to be normal. **(Savage, M.V. et al., 1990, Wilkins B.W. et al., 2007)** However, since VIP is not completely absent in cystic fibrosis patients, this observation in and of itself does not rule out VIP as a potential contributor. Thus the role of VIP in active cutaneous vasodilation remains a mystery.

Another potential contributor to the mechanism of active cutaneous vasodilation is substance P **(Wong B.J. and Minson C.T. 2006)** Substance P has been localized in human skin **(Hokfelt T.et al., 1980, Holzer P.1998)** causes vasodilation, which includes a NO component, and binds with high affinity to neurokinin-1 (NK-1) receptors **(Wong B.J. and Minson C.T. 2006)** Wong and Minson **(Wong B.J. and Minson**

C.T. 2006) studied the role of substance P and NK-1 receptors in cutaneous active vasodilation using the approach of desensitization of NK-1 receptors via prior administration of substance P. They found that desensitized sites showed a decrease of _35% in active vasodilation suggesting that substance P (or another NK-1 agonist) is a significant contributor to active vasodilation. **(Wong B.J. and Minson C.T. 2006)** The authors did not use a NK-1 antagonist specifically, due to concerns regarding nonspecific effects of available NK-1 receptor antagonists. It remains unclear whether "cleaner" NK-1 antagonists would cause effects similar to those seen with desensitization of NK-1 receptors, and whether substance P or some other NK-1 agonist is the physiological vasodilator contributing to the results they observed. **(Wong B.J. and Minson C.T. 2006)** Additional vasodilators that have been shown to have roles in human active vasodilation are histamine (via H1 receptor activation) **(Wong et al., 2004)** and vasodilator **prostanoids (McCord G.R et al., 2006, Wong et al.., 2004)** demonstrated that H1 receptor activation contributes to active vasodilation by showing a significant decrease in cutaneous vascular responses to whole body heating during blockade of H1 receptors with pyrilamine. Combined pyrilamine plus *N*G-nitro-L-arginine methyl ester (L-NAME) did not cause a further inhibition, suggesting that H1 activation contributes to a portion of the NO

component of active vasodilation **(Wong, B.J., Wilkins, B.W. and Minson C.T. 2004)** H2 receptor blockade with cimetidine did not alter the reflex vasodilation. To evaluate a role for vasodilator prostaglandins in reflex cutaneous vasodilation, **(McCord et al., 2006)** used intradermal microdialysis of ketorolac (a non selective cyclooxygenase inhibitor) and of L-NAME (NOS inhibitor). They noted that ketorolac and L-NAME each caused significant inhibition of the reflex vasodilator response, and that combined ketorolac _ L-NAME resulted in further inhibition compared with either inhibitor alone. Interestingly, cyclooxygenase inhibition did not have any influence on the vasodilator response to local warming of the skin **(McCord et al., 2006)** emphasizing the distinct sets of mechanisms associated with the two cutaneous vasodilator responses **(Johnson J.M. and Kellogg D.L. 2010)** Thus a synthesis of the work of many laboratories over several decades shows a complex mechanism of control of skin blood flow during whole body (reflex) heating. Sympathetic neurogenic vasodilation in human skin is an active process, and the mechanism involves cholinergic nerve co transmission. Several specific vasodilators appear to be involved in the mechanism, which includes roles (or potential roles) for NO, VIP, substance P/NK-1 receptors, histamine, and prostaglandins.

The suppression of evaporative function in mist sauna bathing might comprises highly effective heating and prevention of dehydration. Mist

sauna bathing is to provide more effective sweating and vaso dilating (thermoregulatory) function while less influence on cardiovascular function than dry sauna bathing in humans, the increase in heart rate plateaued in mist. Mist sauna provides less heat stressful environment than dry sauna, inducing less blood pressure rise, less heart rate increase, less dehydration by sweating, less circulatory plasma volume reduction, and more efficacy in vasodilatation and sweating. This means mist sauna is more tender and safer sauna bathing system to the circulatory function than dry sauna with more efficiency on thermoregulatory function. Mist sauna bathing may thus be safer physiologically, and provide more effective vascular dilatation and sweating **(Iwase S. et al., 2013)**

3.8. THERMAL STRESS AND HEAT SHOCK PROTEINS

When cells are exposed to thermal stress, stress proteins called heat shock proteins (HSPs) are up regulated intracellularly, and they are thought to serve as molecular chaperones to prevent protein aggregation and help transport repair proteins. **(Kopeček P et al., 2001)** In addition to these well-characterized intracellular functions of HSPs, researchers have suggested that extracellular HSPs enhance the immune system **(Wang Y et al., 2005)** The most inducible and abundant, and therefore most studied, is HSP72, which was reclassified recently as HSPA1A

(Kampinga et al., 2009) Although various stressors can trigger up regulation of HSP72, thermal stress appears to be one of the most effective stressors to increase the intracellular5 and extracellular6 concentrations of HSP72.

In humans, accumulating evidence has shown that intense exercise can increase extracellular HSP72 **(Febbraio M.A. et al., 2002)** Associated with intense exercise is profuse sweating in response to the elevation in core body temperature. This raises the question of whether heat stress alone in the absence of exercise similarly triggers extracellular HSP72 in humans. Investigators have reported that the elevated extracellular HSP72 level with exercise is not attributed to passive release of intracellular HSP72 from exercising muscles. **(Walsh R.C. et al., 2001)** Instead, hepatosplanchnic organs were at least partly responsible for the active release of the HSP72 into the bloodstream, possibly for systemic use, indicating that mechanical stress is not necessary to increase the extracellular HSP72 level. Furthermore, study showed that psychological rather than physical stress could trigger the systemic release of HSP72 in animal models. **(Fleshner et al., 2004)**

Researchers have reported that an increase in extracellular HSP72 due to exercise was much greater than that due to passive heating. However, they induced passive heat stress with water immersion, in which the head

and face are not heated directly. **(Whitham M. et al., 2007, Mundel T.et al., 2007)**

Whole-body heat stress that includes the head and face (ie, heat stress chamber) might effectively modulate cardiovascular, hormonal, and protective chaperones (extracellular HSP72). For example, cardiovascular work increases to stabilize blood pressure during heat-induced skin vasodilation**. (Rowell L.B. 1974)**

Hormones related to stressful stimuli (eg, catecholamines and prolactin) also should increase in the circulating blood. Prolactin, which is one of these hormones, is an indirect measure of dopaminergic-serotonergic transmitters in the brain. **(Bridge M.W et al., 2003)** The extent to which passive heat stress triggers a cascade of responses is the basis for this study. Therefore, the primary purpose of our study was to determine whether whole-body passive heat stress triggers cardiovascular (heart rate, blood pressure), hormonal (prolactin, catecholamines), and extracellular protein (HSP72) responses that commonly are reported during exercise. We hypothesized that whole-body heat stress would reproduce many of the responses observed with exercise. If passively increasing body temperature elicits many of the exercise-induced responses as hypothesized, whole-body heat stress might produce positive health adaptations during key periods of rehabilitation. Indeed,

people who cannot exercise but need to maintain their fitness status (eg, injured athletes) might be able to use this as an alternative or supplemental intervention during key periods of recovery from injury **(Iguchi M et al., 2012)**

3.9.RESPIRATORY SYSTEM

DIVISION OF RESPIRATORY SYSTEM

A. According to functions of the respiratory system

Air conducting division: Composed of small cavity, nasopharynx, larynx, trachea, bronchi and bronchioles.

Respiratory division: Composed of respiratory bronchioles, alveolar ducts, atrium, alveolar sac and alveoli **(Janquira 1998, Bannister 1995)**

B. According to size of the airway

Large airway: When size is more than 2mm.

Small airway: When size is less than 2mm. **(Sly 2000)**

C. Clinical division of respiratory system

Upper respiratory tract: This includes the nose, nasopharynx and oropharynx

Lower respiratory tract: This includes inlet of larynx, larynx, trachea, bronchi and lungs. Clinical division largely related to spread of infection rather than any further anatomical concept **(Bannister 1995, WHO ARI manual 1993)** But some authors describe upper respiratory tract includes nose to larynx (up to lower border of cricoid cartilage) and lower respiratory tract includes trachea to lungs. **(Crompton 1999)**

LUNGS

The lungs are a pair of respiratory organs situated in the thoracic cavity. They are spongy in texture and right lung is about 60 gm heavier than the left. Both lungs have apex, base, costal and medial surfaces, and anterior, posterior and inferior borders. Right lung is divided by two cleft (oblique& horizontal fissure) into 3 lobes; left lung is divided by a single cleft (oblique fissure) into two lobes. The left upper lobe has a lingular segment corresponding to the middle lobe of the right lung. Each lung has a hilum through which principal bronchi enter the lungs along with arteries, and veins and lymphatics come out.

Each lung lobe is divided into bronchopulmonary segments which are defined as the tertiary or segmental bronchi together with the portion of the lung lobe they supply. These bronchopulmonary segments, ten in number in each lung, are roughly pyramidal in shape, their apices towards the hilum, their bases lying on the surface of the lung.

The trachea bifurcates into right and left principal bronchi. The right principal bronchus, shorter and more vertical than the left, is about 2.5 cm long and enters the root of the right lung opposite the 5^{th} thoracic vertebra. The left principal bronchus, narrower than the right, is nearly 5 cm long and enters the root of the lung opposite the 6^{th} thoracic vertebra. **(Snell 1995)** On entering the lungs, the primary bronchi giving rise to 3 bronchi in the right lung and two in the left lung, each of which supplies a pulmonary lobe. Each lobar bronchus gives of repeated branches to supply bronchopulmonary segment, and by further ramification in ends to atrium. Atrium then leads to rounded alveolar sacs **(Snell 1995, Bannister 1995)**

The wall of the intrathoracic airways contain a spiral layer of smooth muscle which is functionally a syncytium. On contraction, this smooth muscle produces narrowing and shortening of airway. Functional airway smooth muscle reaches upto respiratory bronchioles by term. So, failure of wheezy infant to responds to bronchodilators cannot, therefore, be ascribed to absence of smooth muscle in the airway **(Mckenzie and Silverman 1998)** The intrapulmonary bronchi are lined by pseudostratified ciliated columnar epithelium with some goblet cells. In smaller bronchioles, the goblet cells disappear and ciliated cells are low columnar to cuboidal. Scattered among them are few clara cells and neuroendocrine cells. Terminal bronchioles are lined by ciliated cuboidal

cells. Their walls contain more smooth muscle. Respiratory bronchioles are lined by ciliated cuboidal cells which become simple cuboidal in smaller one. It is then continuous with the squamous epithelium of alveolar sacs and alveoli.

The epithelium of the alveoli is flat and called type I and type II pneumocytes. Type I cells completely cover the luminal surface of the alveoli and type II secretes surfactant. The air in the alveoli is separated from capillary blood by 3 layers of cells and membrane referred to collectively as the blood-air barrier. **(Bannister 1995)**

The cytoplasm of the epithelial cells

The fused basal lamina of closely apposed epithelial and endothelial cells.

The cytoplasm of the endothelial cells.

Particles of less than 300 Da size, if lipid soluble are readily absorbed. Breaks in the intercellular junction may enhance absorption. Cigarette smoke is a potent causes of such breaches. Exposure to smoke in early childhood may lead to increase respiratory disease by this mechanism. **(Mckenzie and Silverman 1998)**

The bronchial arteries supply nutrition to the bronchial tree and to the pulmonary tissue. Bronchial system drains mainly into the pulmonary

venous system. The pulmonary circulation serves the respiratory function and the bronchial arteries are the source of nutrition. Lung tissue is supplied by sympathetic nerves derived from T_2 –T_5 and parasympathetic nerves derived from vagus.

There are two sets of lymphatics, both drain into the bronchopulmonary nodes:

Superficial vessels drain the peripheral lung tissue beneath the pulmonary pleura and flow round the borders of the lung and margins of the fissures.

Deep lymphatics drain the bronchial tree, pulmonary vessels and connective tissue, septa and accompany them towards the hilum, where they drain into the bronchopulmoanry nodes. From upper lobes lymphatics drain to superior tracheobronchial lymph nodes and from lower lobes to the inferior tracheobronchial lymph nodes.

ANATOMICAL DIFFERENCE BETWEEN THE LUNGS OF CHILDREN AND ADULT

There are several anatomical differences between the lungs of child and the lungs of the adult:

1) Conducting airways are proportionately larger than the respiratory airways in children compared with adult.

2) Airway resistance is more in the newborn and young child than in adult.

3) The diameter of the conducting airways are small in the infant than adult and more easily obstructed by inflammation, by mucus secretion and by the foreign bodies.

4) The chest wall and supportive structure of infants are softer so that chest wall retraction during respiratory distress is greater in infants than in older patients.

5) Airway of young infant contains relatively more mucous glands than the airway of adult and there are also age differences in the composition

of the mucus. Increased volume of mucus possibly contributes to airway obstruction in infants.

6) The airway is probably more collapsible in response to pressure changes in early life than in adult.

7) In infants, the collateral pathway of ventilation (the pores of Kohn and canal of Lambert) are less developed but in adult they are well developed and prevent collapse distal to occlusion of small bronchus or bronchioles. **(Haddad and Fontan 2000)**

PHYSIOLOGY OF RESPIRATORY SYSTEM

The obvious goal of respiratory system is to provide oxygen to the tissues and to remove carbon dioxide. To achieve this, respiration can be divided into four major functional events:

1) Pulmonary ventilation, which means the inflow and outflow of air between the atmosphere and the lung alveoli.

2) Diffusion of oxygen and carbon dioxide between the alveoli and blood.

3) Perfusion of the lungs by the flow of blood through the pulmonary capillary which transport O_2 and CO_2 to and from the cell.

4) Regulation of ventilation and other factors of respiration.

PULMONARY VENTILATION

Mechanics of pulmonary ventilation:

The lungs can be expanded and contracted in two ways –

1) by downward and upward movement of the diaphragm to lengthen or shorten the chest cavity and

2) by elevation and depression of the ribs to increase and decrease the anteroposterior diameter of the chest cavity **(Guyton 1996)**

The mechanics of respiration is done by the process of inspiration and expiration. Inspiration is an active process. The movement of the diaphragm account for about 75% of changes in intra thoracic volume. **(Ganong 1999)** Diaphragmatic contraction increases vertical diameter of the chest cavity and contraction of external intercostal muscles draw the ribs laterally increase transverse diameter (Bucket handle effect) and elevates the anterior end of the ribs thereby draw the sternum forward and increase the anteroposterior diameter of the chest cavity (Pump handle effect).**(Snell 1995)** During quiet breathing the intrapleural pressure at the base of the lungs which is about –2.5 mm Hg (relative to

atmospheric) at the start of inspiration, decreases to about –6 mm Hg. The lungs are pulled into a more expanded position. The pressure in the airway becomes slightly negative and air flows into the lung. At the end of inspiration, the lung recoil pulls the chest back to the expiratory position, where the recoil pressures of the lungs and chest wall balance. The pressure in the airway 12 becomes slightly positive and air flows out of the lungs. Expiration during the quiet breathing is positive in the sense that no muscles which decreases intrathoracic volume contract. However, there is some contraction of the inspiratory muscles in the early part of expiration. This contraction exerts a breaking action on the recoil forces and slows expiration. This expiration is a passive process, accompanied by elastic recoil of lung and chest wall.

Work of breathing: The work of inspiration can be divided into three different fractions 1) that required to expand the lungs against its elastic forces, called the elastic work or compliance works 2) that required to overcome the viscosity of the lungs and chest wall structures, called tissue resistance work; and 3) that required to overcome airway resistance, called airway resistance work. During quiet respiration no muscle work is performed during expiration. In heavy breathing or when airway resistance used tissue resistance are great, expiratory work does occur. This is specially true in asthma in which airway resistance increases many fold **(Guyton 1996)** During nasal breathing in infancy,

about 50% total resistance is nasal, 25% from glottis and large central airway and remainder 25% from peripheral. Thus infant are prone to respiratory difficulty with upper airway obstruction. **(Mckenzie and Silverman 1998)**

Compliance of the lungs: The extent to which the lungs expand for each unit increase in transpulmonary pressure is called their compliance (Stretchability). The normal total compliance of both lungs in an adult averages about 200 ml/Cm of H_2O pressure, that is 1 cm of H_2O transpulmonary pressure changes – lungs expands 200 milliliters. **(Guyton 1996, Ganong 1999)**

Surfactant: Surfactant is a surface tension lowering agent lining the interior of the alveoli produced by type II alveolar epithelial cells. Surfactant is a mixture of Dipalmitoylphosphatidyl choline (DPPC), phosphatidyl glycerin, other lipid and proteins. It prevents collapse of the alveoli at expiration and prevents pulmonary oedema. Surfactant is important at birth for normal breathing **(Ganong 1999)**

Dead space and uneven ventilation: Since gas exchange in the respiratory tract occurs only in the terminal portions of the airways, the volume of air that merely fills the conducting passage without taking part in the gas exchange is called the dead space. In an average man it is equal to 150 ml and children is 2.2 ml/Kg. **(Silverman 1998)** Because of

this dead space, the amount of air ventilating the alveoli or alveolar ventilation is (500-150) X12 or 4.2L/m. Because of the dead space, rapid, shallow breathing produces much less alveolar ventilation than slow, deep respiration at the same respiratory minute volume (tidal volume times respiratory rate).

It is convenient to distinguish between the anatomic dead space (respiratory tract volume excluding the alveoli) and the physiological (total) dead space (volume of air not equilibrating with blood). In health, the two dead spaces are identical; but in disease states, some of the alveoli may be underperfused or some may be overventilated. The volume of air in the nonperfused alveoli and any volume of air in the alveoli in excess of that necessary to arterialize the blood in the alveolar capillaries are part of the physiological dead space. **(Ganong 1998)**

Lung volumes and capacities: The amount of air that moves into the lungs with each inspiration or the amount that moves out with each expiration is called the “tidal volume”. The air inspired with a maximal inspiratory effort in excess of tidal volume is the “inspiratory reserve volume”. The volume expelled by an active expiratory effort after passive expiration is the “expiratory reserve volume” and the air left in the lungs after a maximal expiratory effort is the “residual volume”. The space in the conducting zone of the airways occupied by gas that does

not exchange with blood in the pulmonary vessels is the “respiratory dead space”. The volume of air that can be forcefully expired after a normal expiration is called “inspiratory capacity” and the volume of air that remains in lung after a normal expiration is called “functional residual capacity” which is the sum of expiratory reserve volume and residual volume. ”Total lung capacity” is the volume of air that remain in lungs after forceful inspiration “The vital capacity” is the amount of air that can be forcefully inspired after a forceful inspiration, is frequently measured clinically as an index of pulmonary function. The fraction of the vital capacity expired in 1 second is ‘timed vital capacity’, also called “forced expired volume in 1 second or FEV_1” gives additional information; the vital capacity may be normal but the FEV_1 greatly reduced in diseases such as asthma. The amount of air inspired per minute is “pulmonary ventilation” or “respiratory minute volume” is normally about 6 L (500 ml/breathX12 breaths/min) in adult.

DIFFUSION

Diffusion of gases across the respiratory membrane in the lungs occurs passively along concentration gradient of different gases. CO_2 is 20 times more diffusible than O_2. Therefore the pressure differences that cause CO_2 diffusion are far less than the pressure differences required to cause O_2 diffusion. O_2 flows "downhill" from the air through the alveoli and blood into the tissues, whereas CO_2 flows "downhill" from the tissues to the alveoli. In each minute 250 ml of O_2 is taken up by the body and 200 ml of CO_2 is excreted. In the blood is mainly transported in combination with hemoglobin, and the oxygen-hemoglobin dissociation curve relating the percentage saturation of the O_2 carrying power of the hemoglobin to tissue. Percentage saturation of O_2 is influenced by P^H, temperature and 23DPG. When P^H, Temperature, 23DPG, these causes shifting of the curve to the right means increase dissociation of O_2 from hemoglobin, affinity of hemoglobin and increase P_{50} (PO_2 at which hemoglobin is half saturated) and vice versa **(Ganong 1998)**

CO_2 is chiefly carried as bicarbonate and in combination with proteins,

besides the small fractions of both gases dissolved in plasma. Alveolar ventilation is closely related to CO_2 excretion. If alveolar ventilation is reduced in proportion to CO_2 excretion, the arterial PCO_2 will rise and if alveolar ventilation become excessive, the arterial PCO_2 will fall. PCO_2 reflects alveolar ventilation and the production of CO_2.

PERFUSION

It is the flow of mixed venous blood through the pulmonary arterial circulation, distribution of blood to the capillaries of the gas exchange units and removal of it from the lungs through pulmonary veins. The pulmonary blood flow is not distributed uniformly throughout the lungs; it is greatest in the dependent regions and least in the superior regions. Regional blood flow is also governed by local factors, the most important of which is vasoconstriction secondary to alveolar hypoxia. Thus blood flow is diverted from poorly ventilated areas, and the matching of ventilation and perfusion is preserved. The ratio of pulmonary ventilation to pulmonary blood flow for the whole lung at rest is about 0.8 (4.2L/min ventilation divided by 5.5L/min blood flow). Ventilation perfusion ratio is altered in many cardio respiratory diseases **(Ganong 1998)**

REGULATION OF RESPIRATION

Rhythmical discharges originating from the 'respiratory center' in the brain stem provide the basis for co-ordinated respiratory movements. From the respiratory center impulses travel in the autonomic fibres to reach the spinal motor neurons which drive the respiratory muscles. Impulses mediating conscious changes in breathing travel via the pyramidal tracts. The activity of the respiratory center is modified by a variety of chemical and neural stimuli so that respiration can meet the changing metabolic needs of the body. Chemical stimuli arises from peripheral and central chemoreceptors, sensitive to changes in H^+, CO_2 and O_2 concentration of the blood. Ventilation is increased when the peripheral chemoreceptors in carotid and aortic bodies are stimulated by hypercapnia, acidosis or hypoxia. Central chemoreceptors in the brain stem are stimulated by increased in H^+ concentration of CSF. A rise in PCO_2 of the arterial blood is accompanied by increasing acidity of both blood and CSF, and therefore stimulates both central and peripheral chemo receptor.

PULMONARY FUNCTION TESTS (PFT)

Function of the respiratory system is to provide sufficient oxygen and wash out carbon dioxide from the body. Optimum gas transfer is effected

Table.1 : Obstructive vs restrictive lung disease		
Obstructive		**Restrictive**
Spirometry		
FVC	Normal or reduced	Reduce
FEV_1	Reduced	Reduced
FEV_1/ FVC	Reduced	Normal
FEF_{25-75}	Reduced	Normal or reduced
PEFR	Normal or reduced	Normal or reduced
Lung volumes		
TLC	Normal or increased	Reduced
RV	Increased	Reduced
RV/TLC	Increased	Unchanged
FRC	Increased	Reduced

by ventilation and perfusion, depend on many variables. Many of these factors can be measured to study composite pulmonary function. Dynamic lung volumes and capacities can be assessed, so also the pressures, and flow-volume rates. Lung compliance and elasticity, airway resistance and respiratory rate contribute to the ultimate function. Finally, the effect of respiratory function can be monitored by arterial blood gas estimation which reflects adequacy of ventilation, perfusion and diffusion. Theoretically, all the above mentioned parameters can be studied to assess pulmonary function.**(Amdekar and Ugra 1996)**

The major clinical indication for performing pulmonary function tests are as follows **(Swaminathan 1999)**

1) To determine if symptoms and signs such as dyspnoea, cough and cyanosis are of respiratory origin.

2) To characterize pulmonary diseases physiologically. Although PFTs are not diagnostic for a specific pulmonary disorder, they may suggest disease etiology.

3) To monitor the course of lung function impairment. PFTs often provide more sensitive, objective and quantitative information concerning changes in lung function than patient history and physical examination.

4) To determine the effectiveness of therapy e.g. aerosol bronchodilator treatment in asthma and steroids in interstitial lung diseases.

5) To assist in the preoperative planning of general anesthesia and in anticipating the need for postoperative oxygen and or assisted ventilation. Preoperative pulmonary function evaluation is particularly important in patients with chest wall deformities e.g. scoliosis, collagen vascular diseases and neuromuscular diseases

TYPES OF PULMONARY FUNCTION TESTS

1. **Ventilatory function** can be assessed by :

Spirometry: It will give the results of the volumes and flow rates, flow volume loops peak expiratory flow rate, Volume-Time Curve combined resistance of lung and airway.

Bronchial provocative tests: Aerosol bronchodilators, histamine, methacholin and exercise challenge.

Peak expiratory flow rate (PEFR): Can be measured by peak flow meter.

Plethosmography: To see [will give the results of total lung capacity (TLC), Functional residual capacity (FRC), Residual volume (RV), and Air way resistance (R_{aw})], total lung volume.

Gas dilution: (helium dilution in closed circuit or N_2 wash out in an open circuit) - For lung volumes (Total lung capacity).

Oesophageal pressure: For lung volumes (Total lung capacity)

Single breath or multiple breath nitrogen (N_2) wash out: To see distribution of ventilation

Forced oscillator: To see respiratory resistance (airway, lung and chest wall resistance)

Pneumotachograph: To see flow.

Ventilatory response to exercise or sleep study by- pediatic pneugram.

2. Diffusion of gas (Gas exchange) can be assessed by-

Blood gas analysis: To see gas exchange. O_2 and CO2 through the respiratory membrane.

Measurement of diffusing capacity: The carbon monoxide (CO) method.

Pulse oximetry: To see oxygen saturation.

3. Perfusion can be assessed by catherization.

4. Ventilation-perfusion can be assessed by radionuclide lung scan.

VENTILATORY FUNCTION TESTS

Spirometry

Spirometry is indicated in all the children with diagnosis of asthma, chronic/recurrent cough or wheeze exercise induced cough or breathlessness and with recurrent respiratory manifestations. **(Amdekar and Ugra 1996)** Spirometry can be reproducibly done from the age of 5 years but these values should be interpreted with individual considering age, sex, height and nutritional status **(Faridi et al., 1994, Chowgule et al., 1994)** Subdivision of lung volumes show changes in different lung diseases that help us to understand the nature of the defect.

Spirometry measures the volume of air exhaled from the lungs during a maximal expiratory maneuver. The forced vital capacity is the total volume of air that can be exhaled after a full inspiration. Though it is measured by spirometry, it is technically a volume and not a flow rate. Forced expiration is begun at TLC and ends at RV and usually takes less than 3 seconds. Forced expiratory volume in 1 second FEV_1) is the volume of air forcefully expired from full inflation in the first second. Both FVC and FEV_1 are recorded in litres. Healthy children are able to exhale>80% of their FVC in 1 second. There is a trend for the FEV_1/FVC ratio to decrease slightly after early adulthood.

Since children younger than 7 years may not inspire to TLC or exhale to RV, valuable information concerning airway function in this age group can be obtained by a partial 'flow volume curve' measuring maximal expiratory flow at FRC (V_{max} FRC). Any spirometer must calculate or display the FVC, FEV_1, and PEFR. Healthy children and adolescents aged 6 years to 16 years perform pulmonary function studies as reproducibly as healthy adults **(Chowgule et al., 1994)**

Interpretation of spirometry: Spirometry not only allows the characterization of a patients lung function against reference values but also defines the disease class. Most lung diseases can be classified as obstructive, restrictive or mixed- type processes. The VC is decreased in both obstructive and restrictive disease but while the RV is increased due to gas trapping in obstructive disease resulting in an increased RV/TLC ratio, the RV, FRC and TLC are all proportionately reduced in restrictive disease. The configuration of the flow-volume and volume-time curves when taken from a maximal forced expiration can provide valuable information about the disease class when compared with the normal curve. In obstructive diseases, flow decreases rapidly as gas exhaled giving a flow volume curve which is convex towards the volume axis. In restrictive disease, the curve shape is normal but smaller than the normal curve.

Spirometric data interpretation should include an assessment of the quality of the study. The following criteria have been laid down for an acceptable test:

(a) Appropriate curve shape which is artifact free

(b) Sustained expiration for at least 3 seconds

(c) At least 3 forced vital capacities within 10% of the best effort and

(d) Satisfactory effort by the patient as observed by the tester.

Peak Expiratory Flow Rate (PEFR) as a measurement of ventilatory function was introduced by Adorn in 1942, and was accepted in 1949 as an index of Spirometry. **(Jain SK et al., 1983)** By definition, it is "the largest expiratory flow rate achieved with a maximally forced effort from a position of maximal inspiration, expressed in litres/min" **(Prakash S. et al., 2007)** PEFR is considered as the simplest index of pulmonary function to assess the ventilatory capacity. It is effort dependent and reflects mainly the calibre of the bronchi and larger bronchioles, which are subjected to reflex bronchoconstriction **(Prakash S et al., 2007)** It is relatively a simple procedure, and may be carried out in the field using portable instruments. The average PEFR of healthy young Indian males and females are around 500 and 350 litres/minute

respectively **(Dikshit M.B. et.al., 2007)** The PEFR reaches a peak at about 18-20 years, maintains this level up to about 30 years in males, and about 40 years in females, and then declines with age. Pulmonary function tests (PFTs) are one of the indicators of the health status of the individuals and could be used as a tool in general health assessment **(Holger J. et al., 2000, Prakash S. et al., 2007)**

Through steam bath the human system is exposed to a positive heat stress and the human system tries to retain homeostasis by the above mentioned mechanisms to maintain the normal body temperature by sweating and normal levels of po2 and pco2 by hyperventilation which promotes the lung function.

5. METHODOLOGY

Materials and Methods

Study design : *Experimental pre post study*

Study population :

The present study was conducted in Government Yoga and Naturopathy Medical College Hospital, Arumbakkam, Chennai – 600 106. The subjects were forty healthy student volunteers, from Government Yoga and Naturopathy Medical College Hospital, Arumbakkam, Chennai – 600 106. They were given steam bath, once a week over a period of three months, totally twelve sessions.

Ethical committee clearance: Clearance from the Institutional ethical committee was obtained prior to the conduct of the study.

Informed consent:

All details about the study and procedures were explained in detail and informed consent was obtained from the study participants.

Selection of the subjects:

Inclusion criteria:

- Healthy Men and Women age :18 – 35 years

- **Exclusion criteria:**
- Physically challenged
- Anyone who recently underwent surgery
- Women during menstrual cycle
- Pregnant women
- Regular Smokers and Alcoholics

Data collection and Analysis:

Measurement of the anthropometric indices:

Standing height: Measuring tape was used to measure the standing height in centimeters.

Weight: Weight was recorded in kilograms using the portable weighing machine.

Body Mass Index: BMI was calculated by using the formula.

BMI= weight (in kg)/ht in meters2 (Quetelet index)

Measurement of pulmonary function test:

Equipment: pulmonary function measurements namely forced vital capacity (FVC), forced Expiratory volume in one second (FEV1), Forced

expiratory flow rate25-75% (FEV 25-27%) and peak expiratory flow rate (PEFR) was measured using the digital spirometer (RMS Helios 401).

Fig.1.RMS Helios 401

Procedure

Pre test:

- The subjects were asked to remain relaxed for at least 30 minutes prior to the test.
- They were made to wear comfortable clothing.
- The test was not performed for at least two hours after consumption of heavy meal.

Spirometry:

- The procedure for performing spirometry was explained to the subjects.
- They were seated in chair and instructed to take a large breath to full inspiration through the nose.
- Nose clips were used to prevent air leakage from the nose.
- The mouth piece was placed into the subject's mouth and he was asked to place his lips and teeth around his mouth piece to form a tight seal.
- The subject was instructed to breathe out hard and quickly for at least 6 seconds until all the air is expelled.
- At least 30 seconds was left between efforts to enable the patients to recover.
- A minimum of three and a maximum of eight efforts were attempted.
- The shape of the flow /volume or volume / time curves was observed to detect poor effort.

- Vital Data, Lung function parameters were recorded using Digital spirometer (RMS Helios 401), BMI, were recorded at the beginning as baseline value and again at the end of the study i.e. 12th week.

Procedure of Steam bath:

- The subject was made to sit inside the steam cabin with minimal dressings after drinking water and with a cold compress on the head. They were exposed to steam of 104ºF (40 ºC) – 116º F (46º C) for 12 - 15 minutes or until perspiration on forehead appears, whichever occurs earlier. The subject was made to come out of the steam cabin and directed to cold shower.

- The pulmonary function test was done prior to the steam bath treatment at the beginning of the study and at the end of steam bath at the end of twelve weeks period.

Statistical Analysis Plan:

Data was expressed as Mean and SD. Pre post data comparison was done using paired t-test by R statistical free software version 3.2.

5. RESULTS

Table.2.Anthropometric parameters of the Study subjects

Variable	Mean±SD
Age (Yr)	16.38±1.98
Height (cm)	151.2±8.27
Weight (Kg)	56.53±14.68
BMI (Kg/m^2)	19.2±2.89

Data expressed Mean±SD. BMI-Body mass Index,

Table.2. showed the anthropometric parameters of the study participants. Mean average of the subject was 16.38 yrs with height of 151.2 cm and weight about 56.53 kg. The Mean BMI was 19.2 kg/$m^{2.}$

Table.3. Resting cardiovascular parameters of

Before and after Steam Bath

Variable	Before	After	P value
Heart rate (bpm)	70.49±8.71	68.42±7.30	**0.05**
SBP (mmHg)	118.86±5.25	114.86±6.90	**0.04**
DBP (mmHg)	76.29±5.82	72.70±8.98	**0.05**
PP (mmHg)	92.82±10.8	89.72±9.87	0.06

SBP- Systolic blood pressure, DBP- Diastolic blood pressure,

PP - Pulse pressure

Resting cardiovascular parameters also showed a significant ($P<0.05$) reduction immediately after application of steam bath in the participants. Heart rate, SBP, DBP and PP showed a significant reduction after taking the steam bath showed the parasympathetic domination over sympathetic nervous system.

Table.4.Weight, Body Mass Index and Waist hip ratio

Before and after Steam Bath

Variable	Before	After	P value
Weight (Kg)	56.53±14.68	52.72±11.90	**0.05**
BMI (Kg/m^2)	19.2±2.89	17.6±1.37	**0.05**
Waist hip ratio	0.83±0.01	0.81±0.01	**0.01**

Data expressed Mean± SD.BMI – Body Mass Index

Weight and Body mass Index also got significant (P<0.05) reduction and Wait hip ratio got significant (P<0.05) reduction after steam bath in healthy volunteers.

Table.5. Comparison of effect of Steam Bath on Lung function parameters.

Variables	Steam Bath		P value
	Before	After	
FVC (L/min)	3.48±0.24	3.91±0.76	**0.03**
FEV1(L/min)	3.23±0.39	3.57±0.48	0.43
FEV1/FVC ratio (%)	86.96±3.64	93.75±4.80	**0.02**
FEF 25-75% (L/min)	3.38±0.73	4.16±0.57	**0.04**
PEFR (L/sec)	5.12±1.90	6.08±0.96	**0.03**
SVC (L/min)	2.38±0.47	2.88±0.82	**0.03**
MVV (L/min)	91.26±7.41	95.26±6.49	0.23

Data Expressed Mean±SD.

FVC Forced vital capacity

FEV1 Forced Expiratory Volume in 1 Second

FEV1/FVC ratio	Forced Expiratory Volume in 1 Second / Forced vital capacity ratio
FEF	Forced expiratory flow
MVV	Maximum Voluntary Ventilation
PEFR	Peak Expiratory Flow Rate
SVC	Slow Vital Capacity

Immediately after steam bath, there was a significant ($P<0.05$) improvement was in the pulmonary function test in the subjects.

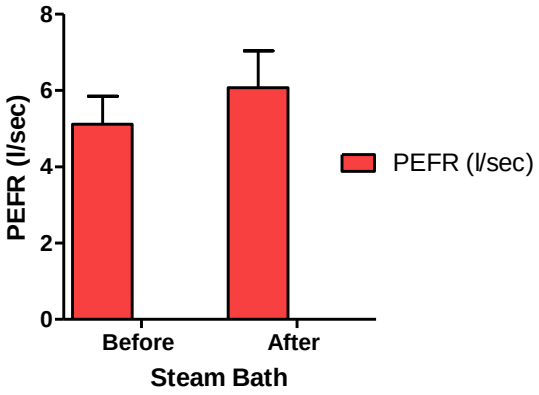
FVC (3.48±0.24 vs 3.91±0.76 L),

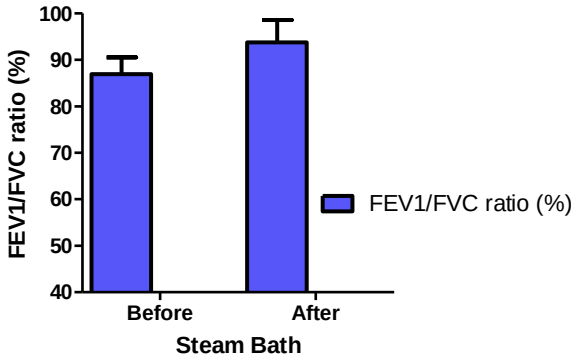
FEV1/FVC ratio (86.96±3.64 vs 93.75±4.80),

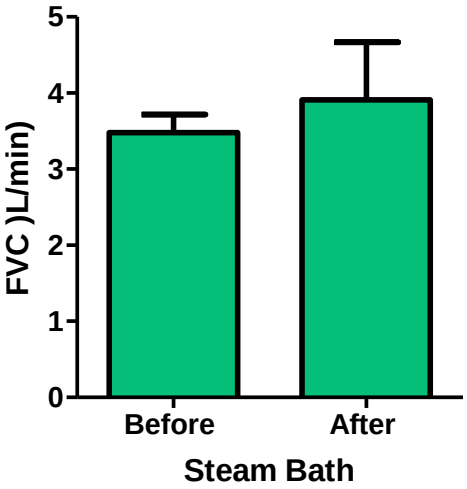
FEF 25-75% (3.38±0.73 vs 4.16±0.57 L/min),

PEFR (5.12±1.90 vs 6.08±0.96 L/sec) after steam bath showed significant ($P<0.05$) improvement.

Slow vital capacity and Maximum voluntary ventilation also increased immediately after steam bath intervention in the participants.


8
6
4
2
0
PEFR (l/sec)
Before
After
Steam Bath
PEFR (l/sec)


100
90
80
70
60
50
40
FEV1/FVC ratio (%)
Before
After
Steam Bath
FEV1/FVC ratio (%)


5
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FVC)L/min)
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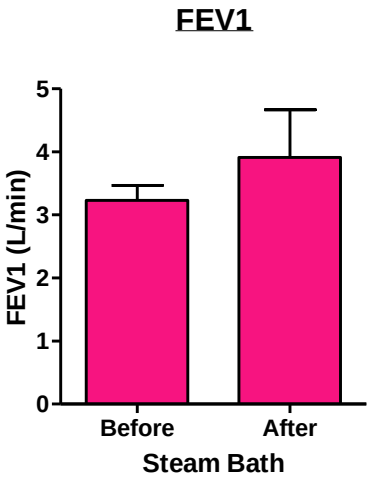
Steam Bath


FEV1
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FEV1 (L/min)
Before
After
Steam Bath

6. DISCUSSION

This Experimental pre post study was designed to analyze differences in the respiratory health status of healthy volunteers before and after steam bath.

In this study, there was significant increase in PEFR value after steam bath. Peak expiratory flow rate (PEFR), which is also termed maximal expiratory flow, occurs shortly after the onset of expiration. The PEFR, more than the other measures, is dependent on participant's effort, thus signifying the capacity of expiratory muscles.

In the present study FEF 25%-75% was also significantly increased from 3.38±0.73 to4.16±0.57. Increase of FEF25%-75% in healthy individuals suggests that the airways in general are widened improving the free flow of air during respiration.

In this study, we investigated the effect of 12 weeks of steam bath (once a week) on PEFR value of the healthy individuals.

Most of the previous studies had used sauna as an intervention instead of steam bath have reported a positive association between the intervention and lung function.

Results of the previous studies found that Finnish saunas decrease pulmonary congestion and increase forced vital capacity (FVC), peak

expiratory flow rate (PEFR), and forced expiratory volume in one second (FEV1). **(Laitinen L.A. etal., 1988, Kiss D et al., 1994)**

Kiss D et al., 1994 found out sauna therapy can help respiration in patients with asthma and bronchitis; however, saunas should not be used during the acute phase of a respiratory infection.

V.V. Zinchuk and D.D. Zhadko 2012 found that the effect of a sauna on blood oxygen transport and the prooxidant-antioxidant balance in untrained subjects, in young men, dry-air bath exposure resulted in respiratory alkalosis, increased pO2 and a decreased affinity of hemoglobin to oxygen in the venous blood, which increased the transportation of O2 to tissues.

Ernst E et al., 1990 found through his study that having a Finnish sauna session twice weekly for six months reduced the incidence of the common cold by fifty percent during months 4-6 of the protocol.

Keast M.L. and Adamo K.B 2000 found that during sauna bath, the organism absorbs more warmth from the environment than it is capable to return. Both mean skin temperature and body temperature increase up to 37.6 - 40^{o}C.

Cox NJ et al., 1989 found there was no experience of adverse effects from the sauna, had significant improvements in FEV1 and FVC, and reported that they did not have to expend as much effort to breathe.

Through this study it is found that steam bath improves lung function in healthy volunteers. This study is limited as the study design was not suitable and the sample size is small. As a future study this can be repeated in diseased individuals with the larger sample size and for a longer duration.

7. CONCLUSION

- There were noteworthy improvements in pulmonary function parameters in healthy volunteers. The healthy volunteers showed marked improvement in spirometry values especially the PEFR value.
- There was significant reduction seen among cardiovascular parameters after the steam bath which implies parasympathetic dominance over sympathetic nervous system.
- Waist hip ratio got significantly reduced after steam bath in the healthy volunteers. This could play a role in weight reduction which would be of utmost importance as an effective intervention in case of obesity.
- Though transient, significant improvement in Lung function is noted after steam bath. Further studies are to be done for sustained improvement in lung functions after steam bath.
- Later steam bath may be recommended as an effective therapy for improving lung function in obstructive pulmonary disorders.

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9. ANNEXURES

PROFORMA

Name: Age: yrs Gender: Male / Female

Occupation: Marital Status: Religion:

Address:

Emergency Contact:

Primary Language(s):

Complaints:

History of present Illness:

Previous Illness:

Personal History:

Diet : Appetite: Digestion:

Sleep: Bowel: Micturition:

Coffee/Tea: with/without sugar Addiction:

Family History:

Treatment History:

History of Allergy to any specific drugs/food, if any:

Obstetrics & Gynaecology history:

Vital data:

Built: Height: cms Weight: kgs

Pulse: beats/min Blood Pressure: mm/Hg BMI:

Waist Hip ratio: Temperature:

GENERAL PHYSICAL EXAMINATION:

SYSTEMIC EXAMINATION:

Cardiovascular System:

Respiratory System: Abdomen:

Nervous System:

Endocrine System:

Genitourinary System:

Locomotor System:

Investigation:

INFORMATION SHEET

We are conducting a study among healthy volunteers of both sexes at Government Yoga & Naturopathy Medical College and Hospital. The purpose of the study is to evaluate the effect of steam bath intervention in pulmonary function test and BMI, Waist Hip ratio and Vital Data in healthy volunteers. The tests we are using are non - invasive and do not have any side effects and no medications are given.

We need your participation in this study. Here we are assessing the pulmonary functions by recording PEFR and vital data.

The privacy of the patients in the research will be maintained throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

Taking part in this study is voluntary. You are free to decide whether to participate in this study or to withdraw at any time; your decision will not result in any loss of benefit to which you are otherwise entitled.

The results of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Signature of investigator Signature of participant

Date:

INFORMED CONSENT FORM

Title of the study: Evaluation of Effect of Steam bath on Pulmonary Function in healthy volunteers.

Name of the Participant:

Name of the Principal Investigator: Dr.M.Pandiaraja

Name of the Institution:

Government Yoga & Naturopathy Medical College and Hospital,

Chennai - 600 106

Documentation of the informed consent

I _____ have read the information in this form (or it has been

read to me). I was free to ask any questions and they have been answered. I am over 18 years of age and, exercising my free power of choice, hereby give my consent to be included as a participant in "Effectiveness of steam bath over pulmonary function in healthy volunteers"

1. I have read and understood this consent form and the information provided to me.

2. I have had the consent document explained to me.

3. I have been explained about the nature of the study.

4. I have been explained about my rights and responsibilities by the investigator.

5. I have been informed the investigator of all the treatments I am taking or have taken in the past _____ months including any native (alternative) treatment.

6. I have been advised about the risks associated with my participation in this study.

7. I agree to cooperate with the investigator and I will inform him/her immediately if I suffer unusual symptoms.

8. I have not participated in any research study within the past month(s).

9. I am aware of the fact that I can opt out of the study at any time without having to give any reason and this will not affect my future treatment in this hospital.

10. I am also aware that the investigator may terminate my participation in the study at any time, for any reason, without my consent.

12. I hereby give permission to the investigators to release the information obtained from me as result of participation in this study to the sponsors, regulatory authorities, Govt. agencies, and IEC. I understand that they are publicly presented.

13. I have understood that my identity will be kept confidential if my data are publicly presented.

14. I have had my questions answered to my satisfaction.

15. I have decided to be in the research study.

I am aware that if I have any question during this study, I should contact the investigator. By signing this consent form I attest that the information given in this document has been clearly explained to me and understood by me, I will be given a copy of this consent document.

For adult participants:

Name and signature / thumb impression of the participant (or legal representative if participant incompetent)

Name _____ Signature_____

Date_____

Name and Signature of impartial witness (required for illiterate patients):

Name _____ Signature_____

Date_____

Address and contact number of the impartial witness:

Name and Signature of the investigator or his representative obtaining consent:

Name _____ Signature_____

Date_____

INFORMATION TO PARTICIPANTS

Investigator: Dr. M. Pandiaraja

Name of Participant:

Title:

You are invited to take part in this research/ study /procedures. The information in this document is meant to help you decide whether or not to take part. Please feel free to ask if you have any queries or concerns. You are being asked to participate in this study being conducted in Government Yoga & Naturopathy Medical College, Chennai – 600 106

What is the Purpose of the Research?

To estimate the effectiveness of Steam bath in pulmonary function in Healthy volunteers

The Study Design: 40 Healthy Volunteers will be participated in the study

Study Procedures

The study involves assessment of pulmonary function using Digital Spirometer, BMI, Waist Hip ratio and Vital Data before and after every treatment session which occurs once a week for duration

of 12 weeks. The data will be recorded at the beginning of the study and at twelfth week for comparison and evaluation of the data.

You will be required to visit the Hospital once a week for about 12 weeks of steam bath treatment. In addition, if you notice any physical or mental changes, you must contact the persons listed at the end of the document.

You may have to come to the hospital (study centre) for examination and investigations apart from your scheduled visit, if required.

Possible Risks to you: Nil

Possible benefits to you: Early assessment of Lung function impairment and its related diseases

Possible benefits to other people:

Estimating the effect of Steam bath helps in validating the treatment hence can be prescribed as evidence based treatment to other people and further research could be done in individuals with respiratory diseases which would wide open its application to diseased.

Confidentiality of the information obtained from you

You have the right to confidentiality regarding the privacy of your medical information (personal details, results of physical examinations, investigations, and your medical history). By signing this document, you will be allowing the research team investigators, other study personnel, sponsors, IEC and any person or agency required by law like the Drug Controller General of India to view your data, if required.

The information from this study, if published in scientific journals or presented at scientific meetings, will not reveal your identity.

How will your decision to not participate in the study affect you?

Your decisions to not to participate in this research study will not affect your medical care or your relationship with investigator or the institution. Your doctor will still take care of you and you will not lose any benefits to which you are entitled.

Can you decide to stop participating in the study once you start?

The participation in this research is purely voluntary and you have the right to withdraw from this study at any time during course of the study without giving any reasons.

However, it is advisable that you talk to the research team prior to stopping the treatment.

CONTACT DETAILS:

DR.M.PANDIA RAJA

+91 - 9952448729

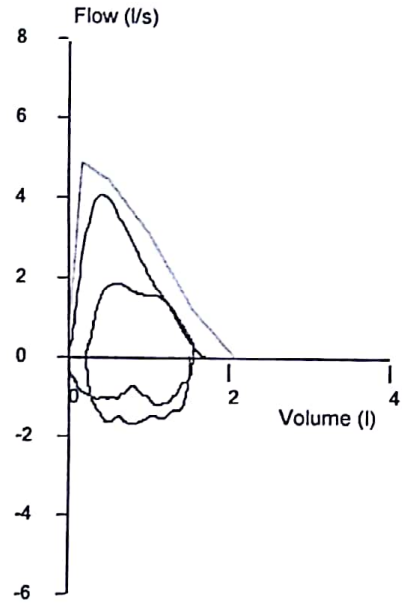
vivek.abimanyu@gmail.com

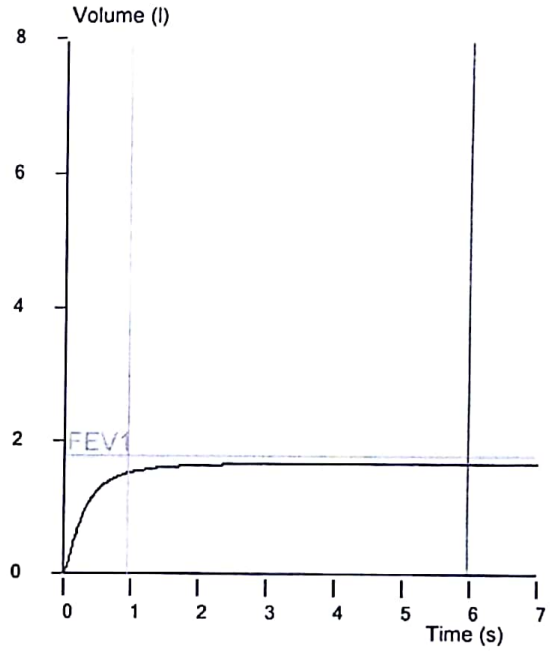
medical equipment europe

Medical Equipment Europe
Abteilung Entwicklung
Dr.-Georg-Schaefer-Str. 14
Germany 97762 Hammelburg

Name:	**Jayalakshmi S**	Height:	152 cm	Age:	54 years	Date Of Birth:	19-01-19(
ID:	**0001**	Weight:	76 kg	Gender:	Female	BMI:	32.9 kg/m

Medication:





Parameter	Unit	Ref	Pre	%Ref	ZScore
FEV1	l	1.79	1.61	90	
FVCex	l	2.12	1.75	82	
FEV1/FVC	%	69	92+		
PEF	l/s	4.90	4.07	83	
MEF25	l/s	1.18	1.29	109	
MEF50	l/s	3.07	2.73	89	
MEF75	l/s	4.48	4.06	91	
MEF25-75	l/s	2.60	2.43	94	
tex	s		7.3		

Comment:

Date:	26-04-2017	Ambient temperature:	23 °C	Technician:	
Time:	10:10	Ambient pressure:	999 hPa		
		Ambient humidity :	50 %		